Community Spatial Data Visualization & Analytics – UrbanScape

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U.S. DEPARTMENT OF ENERGY

Acknowledgment

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Background

- *Increased Distributed Energy Resources (DERs) at building and community level.*

- *Emerging social-spatial issues in urban a DER planning.*

- *Opportunities and constraints in grid modernization.*

- **The key points above require a comprehensive approach to address the intricate relationships among buildings, the city, and the grid system.**
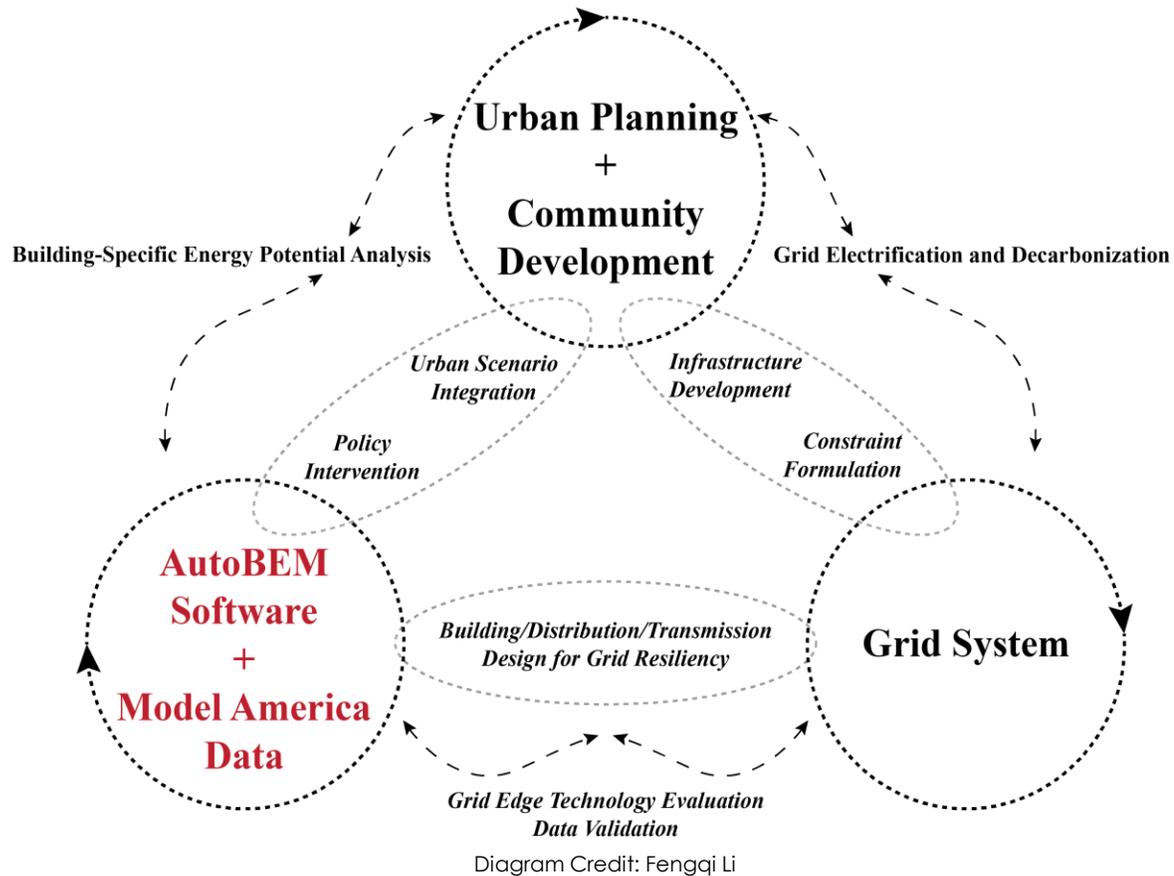

Harvest   Storage   Exchange

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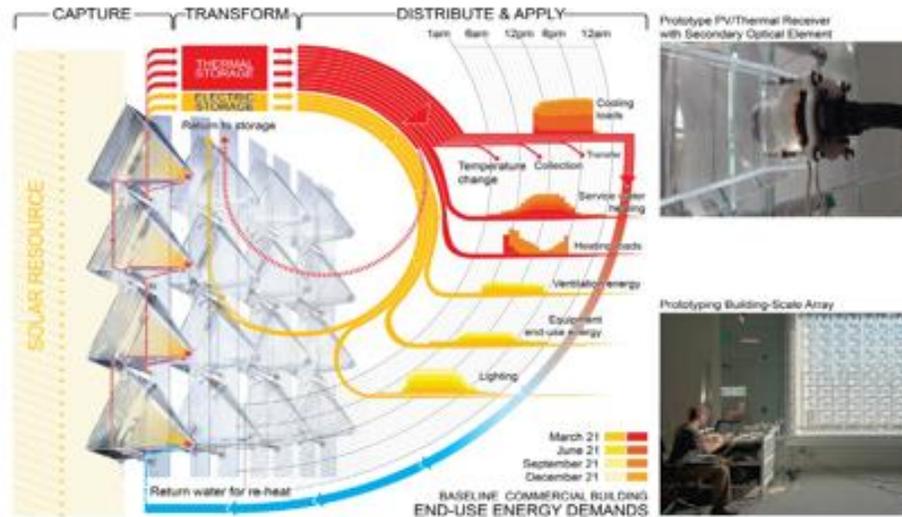
Nation-scale…what is AutoBEM and Model America?

Diagram Credit: Fengqi Li

Automatic Building Energy Modeling (AutoBEM) software

- Licensable from ORNL; U.S. Copyrights AutoBEM, AutoBEMGen, AutoSIM
- Related publications: **bit.ly/AutoBEM**

**Model America** - free model of every U.S. building (**bit.ly/ModelAmerica**)

- **Model America v1.0**

125,714,640 buildings, 124,276,332 simulated 122,930,327 models (97.8%) shared

- OpenStudio (v3.2.0) and EnergyPlus (v9.5)
- State_county.zip (requires free Globus Connect Personal); location-specific requires NDA

- Model America v2.0 in-process (~140M buildings)

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Automatic Building Energy Modeling (AutoBEM) and its Model America dataset

- AutoBEM takes set of building properties as inputs
  - Building Footprint
  - Building Height
  - Building Type
  - Building Age
- AutoBEM develops building energy models using OpenStudio and simulates Models using EnergyPlus
- Internal characteristics and other building properties (occupancy, equipment, insulation, etc.) determined non-intrusively by building type and year built

OpenStudio

EnergyPlus
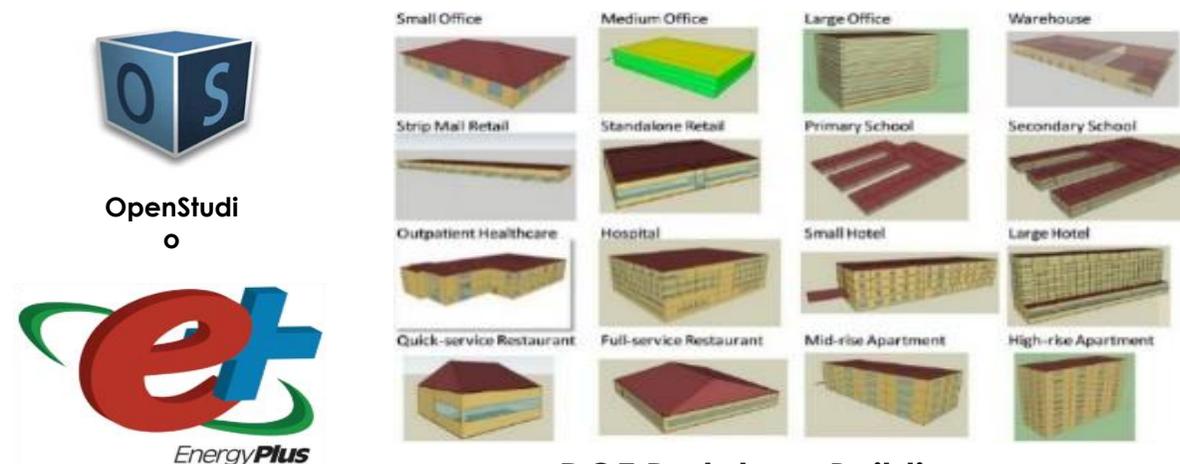
DOE Prototype Buildings

Clark County (Las Vegas) Modeling Example

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Multi-scale Integration based on AutoBEM Software + Model America Data

OpenStudio

DOE Prototype Buildings

1. Ground-Source Heat Pump – Building Level Application

2. Virtual EPB Utility – City/Grid Level Application

3. Environmental Anlysis - State/National Level Application

Clark County (Las Vegas) Modeling Example

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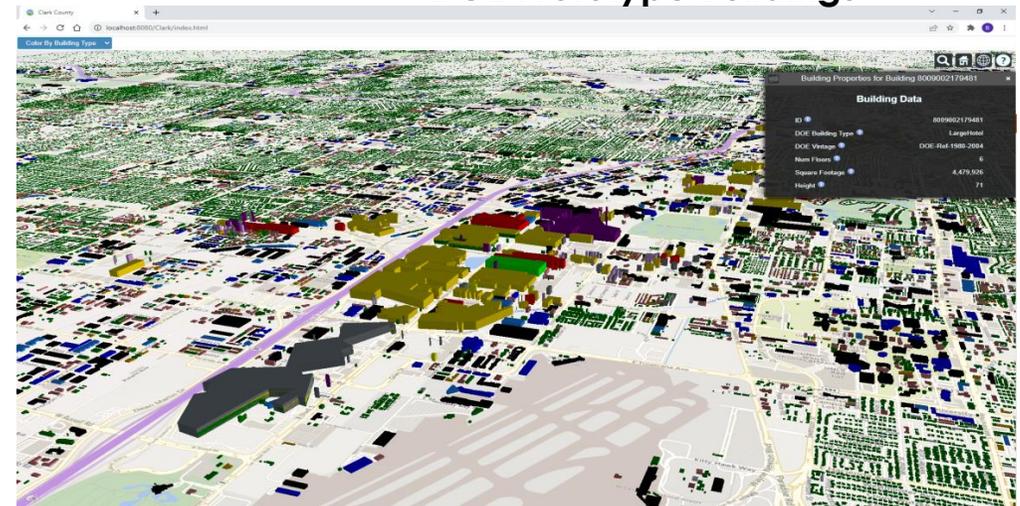
GSHP (Ground-Source Heat Pump) Integration

AutoBEM + Model America + GSHP (Ground-Source Heat Pump)
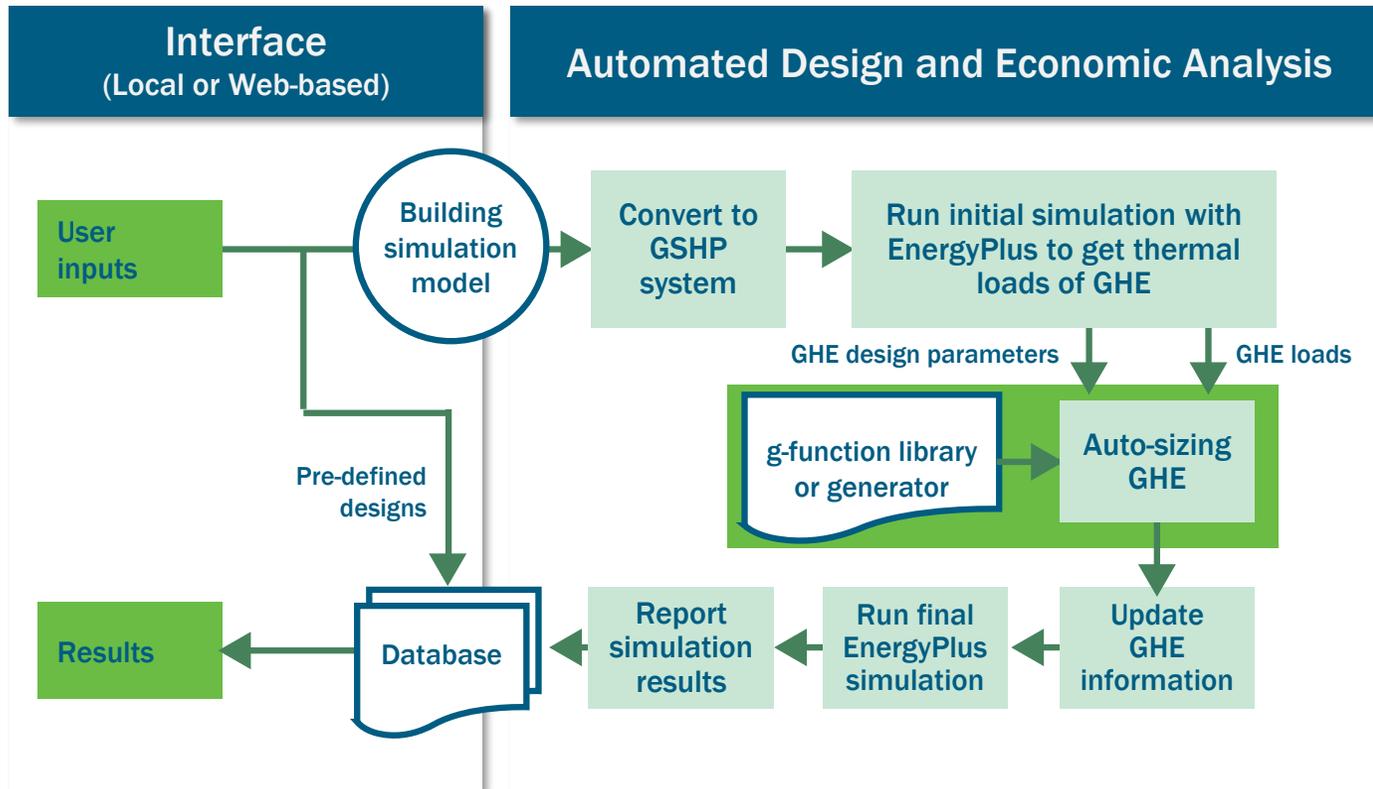
- Utilize the state-of-the-art building energy simulation programs: OpenStudio and EnergyPlus

- Integrated with the latest development in GHE modeling to increase flexibility, speed, and accuracy

- Automatically create building energy models, size HVAC equipment and GHE, and evaluate the economics of GSHP retrofit for almost any existing building in the US

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Tool Interface Development

Development of a GSHP Techno-Economic Analysis Tool
Web Tool Interface and Capability

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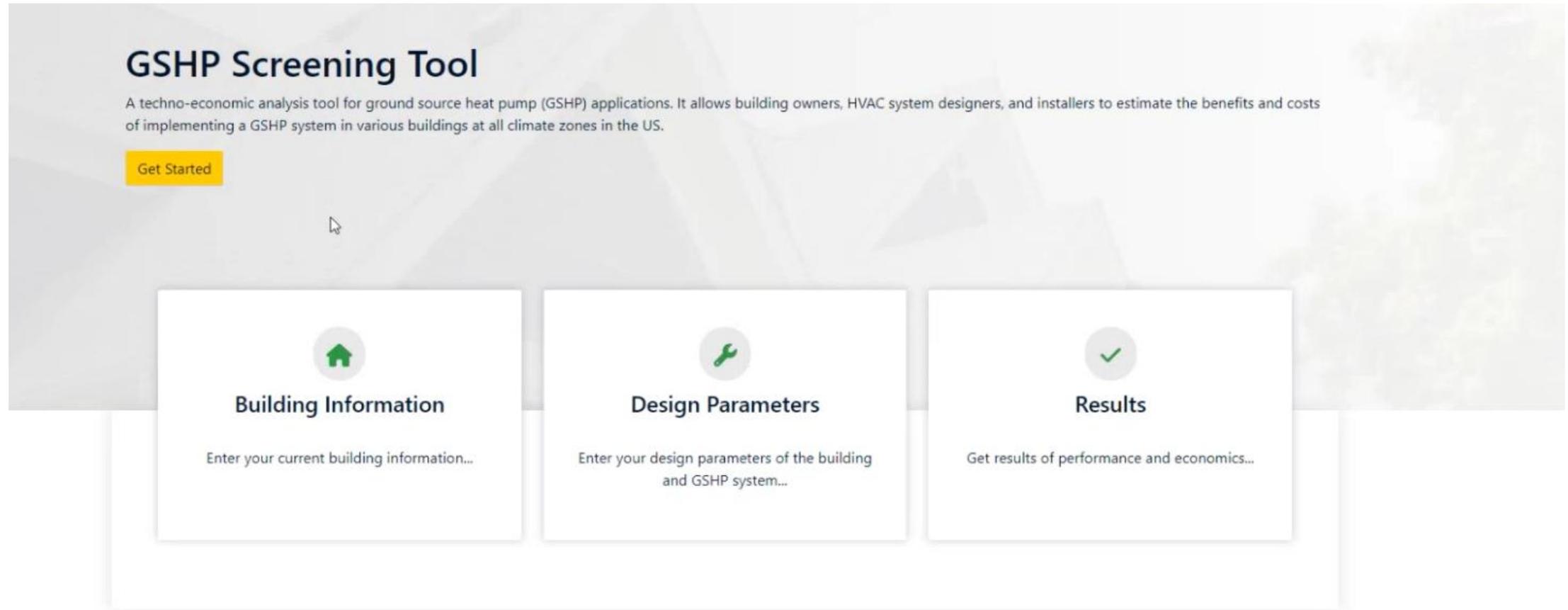
Virtual EPB Integration

The Electric Power Board (EPB) of Chattanooga is a publicly owned utility that uniquely supplies both electricity and internet to southeastern Tennessee.
In this project, ORNL will use EPB's 15-minute electricity consumption data along with GIS data to create a "digital twin", i.e., a calibrated building energy model, for each of the 178,000 buildings in EPB's service territory.

Diagram Credit: Fengqi Li

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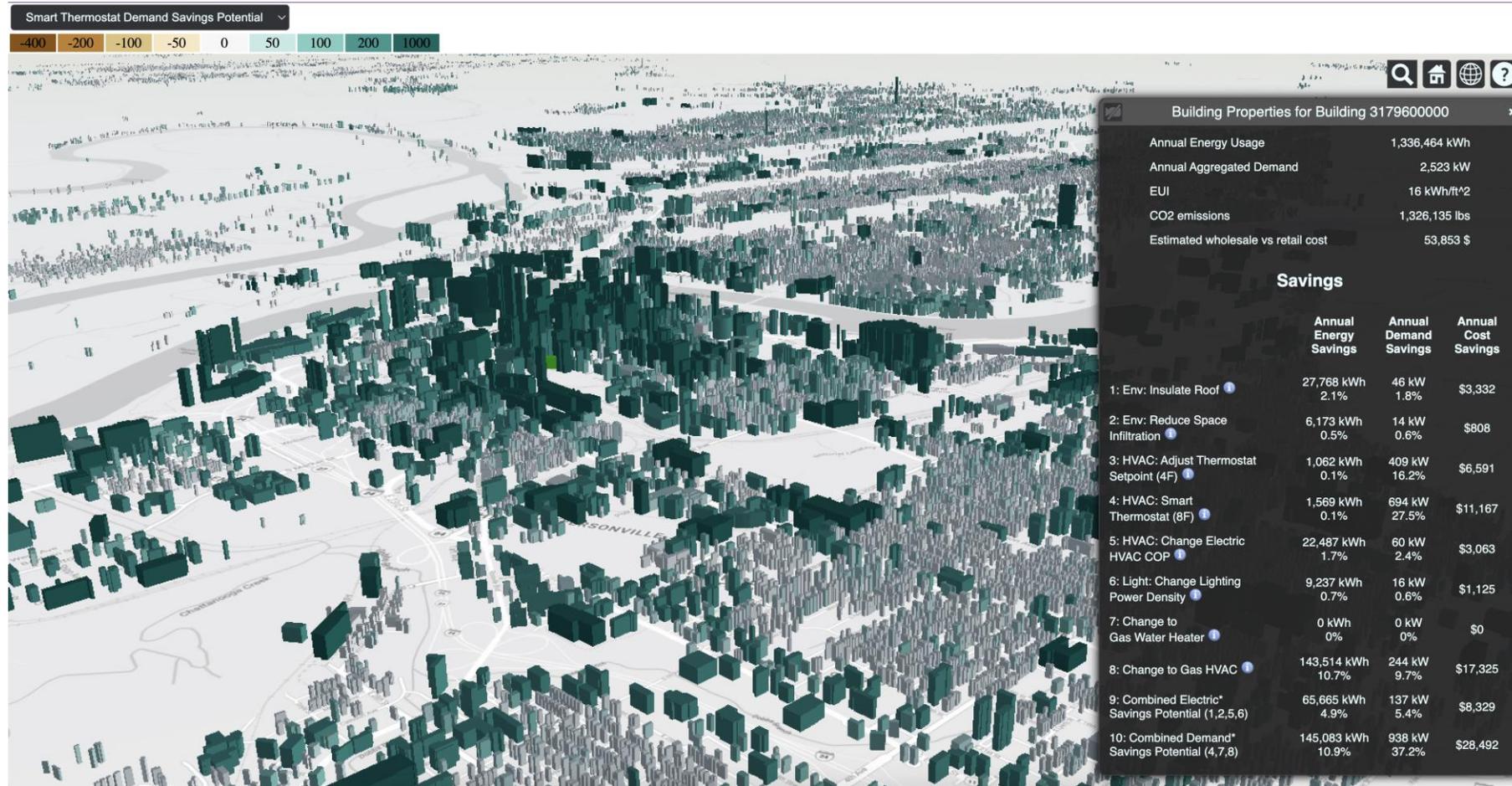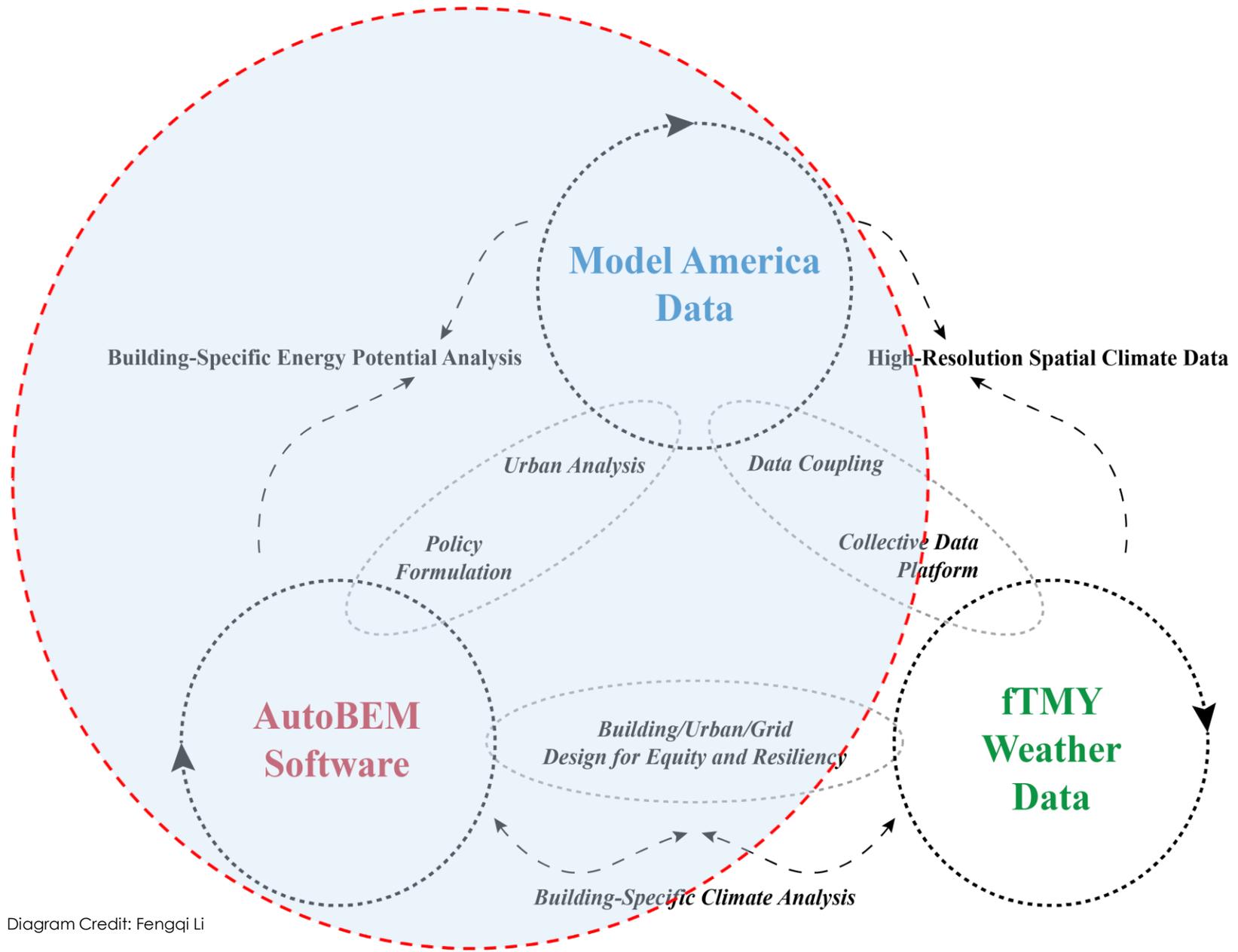
Developing fTMY Weather Files

fTMY weather files were developed (3281 US Counties)

- 4 SSP, RCP Scenarios weather files
- 1980-2100
- Every CONUS county (3,281) and 18 cities
  - Representative cities of each climate zone (intl use)
- 6 Climate Models from various climate institutions around the globe
  - ACCESS-CM2
  - BCC-CSM2-MR
  - CNRM-ESM2-1
    - MPI-ESM1-2-HR
    - MRI-ESM2-0
    - NorESM2-MM
- 9 Weather Variables
  - Air Temp
  - Longwave
  - Shortwave
  - Vapor Pressure
    - Vapor Pressure Deficit
    - Relative Humidity
    - Precipitation
    - Wind
    - Pressure

All of Alaska is in Zone 7 except for the following boroughs in Zone 8: Bethel, Northwest Arctic, Dellingham, Southeast Fairbanks, Fairbanks N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands

International Code Council (2012)

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Southwest Urban Corridor Integrated Field Laboratory (SW-IFL) Integration

- Generation of Publicly-available data and building energy models for more than 2.5 million buildings in Arizona (2,555,152 buildings).

- Environmental impacts through year 2100 under IPCC's SSP-5, RCP-8.5 for each building in Maricopa County (Phoenix, AZ).

Color By Building Type

8559FW8G+F5P-13-15-13-14

Total Energy Projections

Percent changes are calculated from 2020-2040

	Annual Energy	Annual Cost	Annual Emissions
fTMY 2020-2040	9,059,992 kBTU	348,640 $	972.1 Tons CO2
fTMY 2040-2060	3.4 %	3.4 %	3.4 %
fTMY 2060-2080	5.3 %	5.3 %	5.3 %
fTMY 2080-2100	10.8 %	10.8 %	10.8 %

Electricity Projections

Percent changes are calculated from 2020-2040

	Annual Energy	Annual Cost	Annual Emissions
fTMY 2020-2040	9,059,774 kBTU	348,637 $	972.1 Tons CO2
fTMY 2040-2060	3.4 %	3.4 %	3.4 %
fTMY 2060-2080	5.3 %	5.3 %	5.3 %
fTMY 2080-2100	10.8 %	10.8 %	10.8 %

Natural Gas Projections

Percent changes are calculated from 2020-2040

	Annual Energy	Annual Cost	Annual Emissions
fTMY 2020-2040	218 kBTU	4 $	0 Tons CO2
fTMY 2040-2060	215.2 %	215.2 %	215.2 %
fTMY 2060-2080	-100 %	-100 %	-100 %
fTMY 2080-2100	16.2 %	16.2 %	16.2 %

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What is next?

- **Building becomes part of infrastructure system.**
- **DER needs in built environments.**
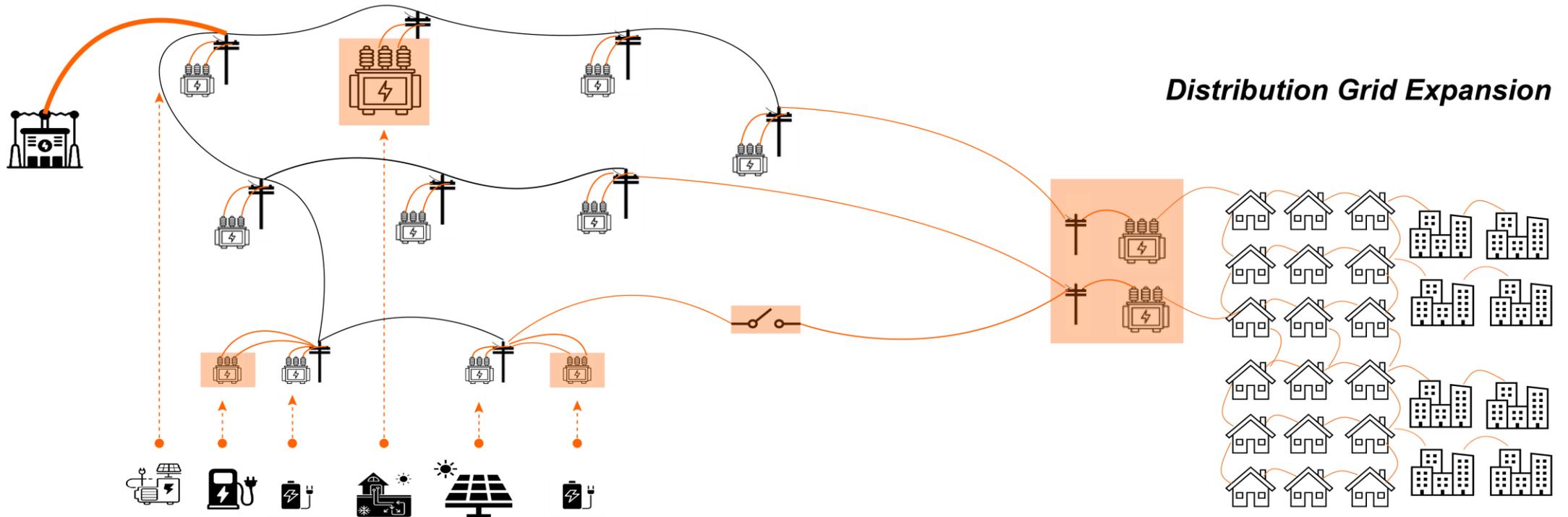- **Shared resilient goals for both urban and grid planners.**

Distribution Grid Expansion

Diagram Credit: Fengqi Li

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A Computational Approach for Community Planning and Development
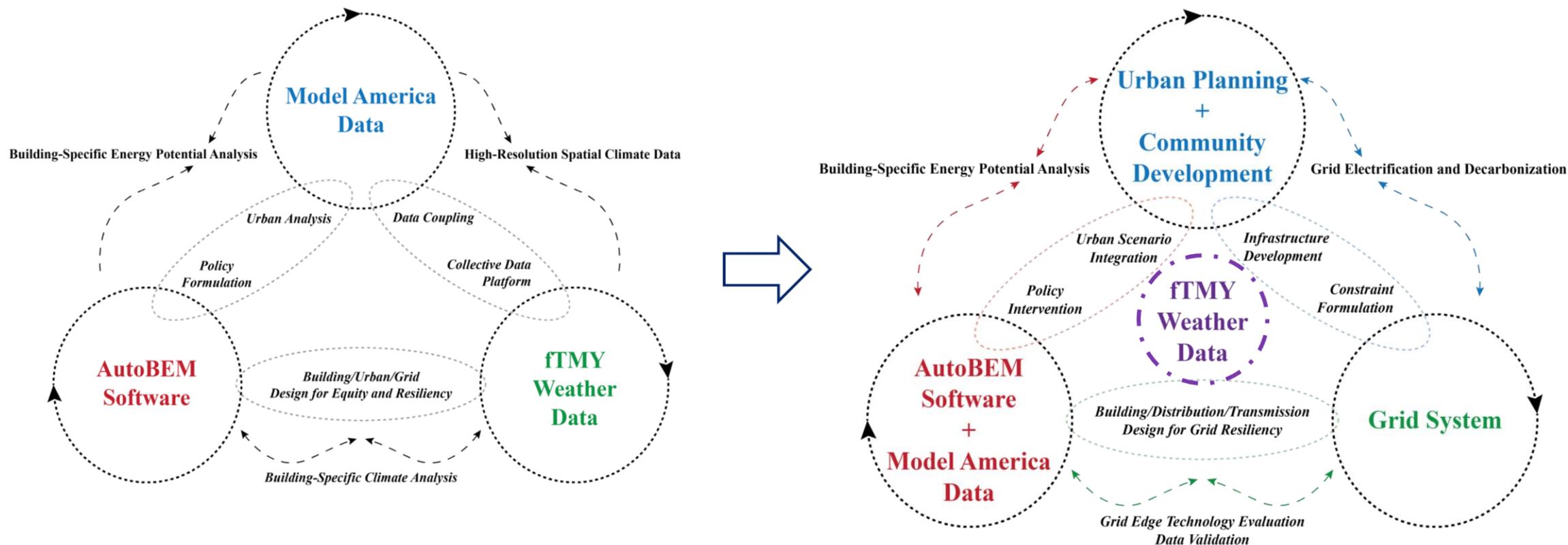
Diagram Credit: Fengqi Li

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Questions

Thank You
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